LAMPIRAN

Lampiran 1 Daftar Konversi Satuan

(Sumber : *Tables And Diagrams For Refigeration & AC-Technicians*)

1. **Panjang (length) = L**

1 milimeter	=	0,0394 inchi	=	1.000 micron	=	0,001 meter
1 centimeter	=	0,3937 inchi	=	0,03281feet	=	0,01 meter
1 meter (m)	=	39,37 inchi	=	3,2808 feet	=	1,0936 yard
1 kilometer	=	3.280,83 feet	=	1.093,61 yard	=	0,6214 mile
1 inchi	=	25,4 mm	=	2,54 cm	=	0,0833 feet
1 foot (ft)	=	30,48 cm	=	0,3048 meter	=	12 inchi
1 yard (yd)	=	0,9144 meter	=	36 inchi	=	3 feet
1 mile	=	1,6093 km	=	5.280 feet	=	1.760 yard

2. **Luas area = A = L^2**

1 cm^2	=	0,155 in^2	=	100 mm^2	=	0,0001 m^2
1 $meter^2$	=	1.550 in^2	=	10,76391 ft^2	=	1,1959 yd^2
1 $inchi^2$	=	645,163 mm^2	=	0,00694 ft^2	=	6,4516 cm^2
1 $foot^2$	=	929,0304 cm^2	=	144 in^2	=	0,1111yd^2
1 $yard^2$	=	0,8361 m^2	=	1.296 in^2	=	9 ft^2

3. **Isi (volume) =v = l^3**

1 cm^3	=	0,001 dm^3	=	0,06124 in^3	=	1.000 mm^3
1 dm^3	=	61,025 in^3	=	0,03531 ft^3	=	1.000 cm^3
1 $meter^3$	=	1.000 dm^3	=	1,30795 yd^3	=	35,3146 ft^3
1 $inch^3$	=	0,0164 dm^3	=	16,3871 cm^3	=	1/1728 ft^3
1 $foot^3$	=	28,3168dm^3	=	0,02832 m^3	=	1,728 in^3
1 $yard^3$	=	764,56 dm^3	=	27 ft^3	=	202 US gal.
1 us gallon	=	3,7854 liter	=	231,1 in^3	=	0,327 UK gal.
1 uk gallon	=	4,5461 liter	=	277,3 in^3	=	1,2009 US gal.
1 us gallon	=	119,24 liter	=	4,2104 ft^3	=	31,5 US gal.
1 barrel (oil)	=	158,9898 liter	=	5,6138 ft^3	=	42 US gal.

4. Berat massa (weight) = m

1 gram (g)	=	0,001 kg	=	15,4323 grain	=	0,0353 ounce
1 kilogram	=	1.000 gram	=	2,204 poun	=	35,274 ounce
1 grain (gr)	=	0,0648 gram	=	0,00228 ounce	=	1/7000 pound
1 ounce (oz)	=	28,3495 gram	=	0,0625 pound	=	437,5 grain
1 pound (lb)	=	0,4356 kg	=	7.000 grain	=	16 ounce
1 short ton	=	907,184 kg	=	2000 pound		
1 metric ton	=	1.000 kg	=	2.204,62 pound		

1 long ton	=	1.016,0469 kg	=	2.240 pound		
1 troy ounce	=	31,1035 gram	=	480 grain		
1 dyne	=	10^{-5} newton	=	0,00102 gram-f	=	1/981 gram-f
1 newton	=	10^{-5} dyne	=	102 gram-f	=	0,2248 lb-f
1 gram-force	=	0,0098 newton	=	980,66 gram-f	=	0,001 kg-f
1 kilogram-f	=	9,8066 newton	=	1.000 gram-f	=	2,2046 lb-f
1 pound-force	=	4,4482 newton	=	453,6 gram-f	=	0,4536 kg-f

5. Energi, Kalor, Usaha atau Kerja (work) = W = F X d

1 erg	=	10^{-7} joulle	=	1 dyn.cm	=	$9{,}486^{-11}$ Btu
1 joule (j)	=	10^{7} erg	=	1 N.m	=	0,228 watt.s
	=	0,1019 kg.m	=	0,00095 Btu	=	0,2389 kalori
1 kilo joule	=	1.000 joule	=	0,9478 Btu	=	238,9 kalori
1 mega joule	=	1.000 kj	=	947,8 Btu	=	0,278 kWh
1 kWh	=	3,6 Mj	=	3.412,76 Btu	=	860,5165 kkal
1 kalori	=	4,1868 joule	=	0,00397 Btu	=	0,4267 kg.m
1 kilo kalori	=	4.186,8 joule	=	3,968 Btu	=	1,1619 watt.h
1 btu	=	1.054,8joule	=	0,293 watt.h	=	0,2522 kkal

6. Daya atau Tenaga (power) = p = W/t

1 watt (s)	=	10^7 erg/s	=	3,413 Btu/h	=	0,8605 kkal/h
1 kilo watt	=	1.000 watt	=	0,9478 Btu/h	=	0,2389 kkal/s
	=	101,97 kg	=	737,56 ft.lb/s	=	1,3596 mt.HP
1 metrik HP	=	753,5 watt	=	75 kg.m/s	=	0,1758 kkal/s
	=	0,9863 Bt.HP	=	542,5 ft.lb/s	=	0,6971 Btu/s
1 British HP	=	745,699 watt	=	550 ft.lb/s	=	1,0138 mt.HP
1 kkal/s	=	4,1868 KW	=	426,7 kg.m/s	=	3,968 Btu/s
1 kkal/s	=	1,1619 watt	=	3.086 ft.lb/h	=	3,968 Btu/s
1 Btu/s	=	1,055 KW	=	778,16 FT.LB/S	=	0,2522 kkal/s
1 Btu/h	=	0,293 watt	=	0,0004 Bt.HP	=	0,2522 kkal/h

7. Tekanan (pressure) = p = F/A

1 pascal (pa)	=	0,0075 mm Hg	=	1 N/m^2	=	10 dyn/cm^2
1 kpa	=	0,2953 in Hg	=	1.000 pascal	=	0,145 lb/in^2
	=	75006 mm Hg	=	0,0102 kg/cm^2	=	0,0098 atm
1 bar(cairan)	=	750 mmHg	=	100 kpa	=	10^6 dyn/cm^2
1 Atmosfir	=	760 mmHg	=	101,325 kpa	=	1,0132 bar
Standar	=	29,921 in Hg	=	1,0332 kg/cm^2	=	14,696 lb/cm^2
1 mmHg (torr)	=	0,3937 in Hg	=	0,00132 kg/cm^2	=	133,322 pascal

1 inchi Hg	=	25,4 mmHg	=	0,03453 kg/cm^2	=	0,0324 atm
1 kg/cm^2	=	7535,559 mmHg	=	14, 22234 lb/in^2	=	0,9678 atm
1 lb/in^2 (psi)	=	51,7147 mmHg	=	0,07031 kg/cm^2	=	0,068004 atm
	=	2,036 in Hg	=	6.894,94 pacal	=	144 lb/ft^2

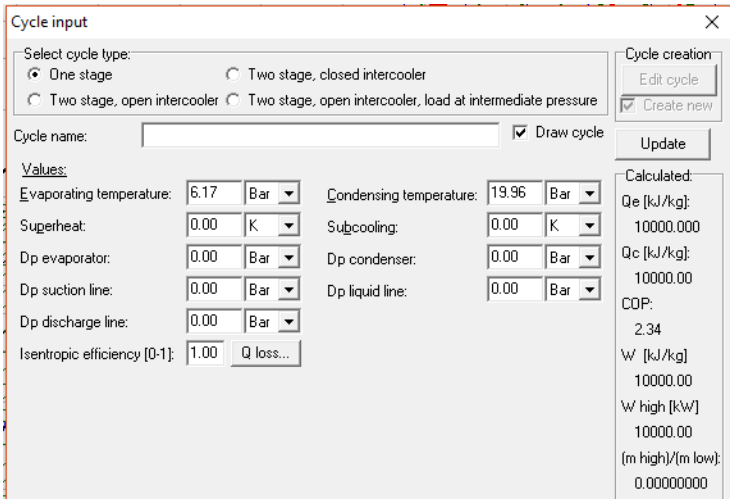
Lampiran 2 Efisiensi *Heat Exchanger*

1. Efisiensi HE pada Tekanan 75 Psi

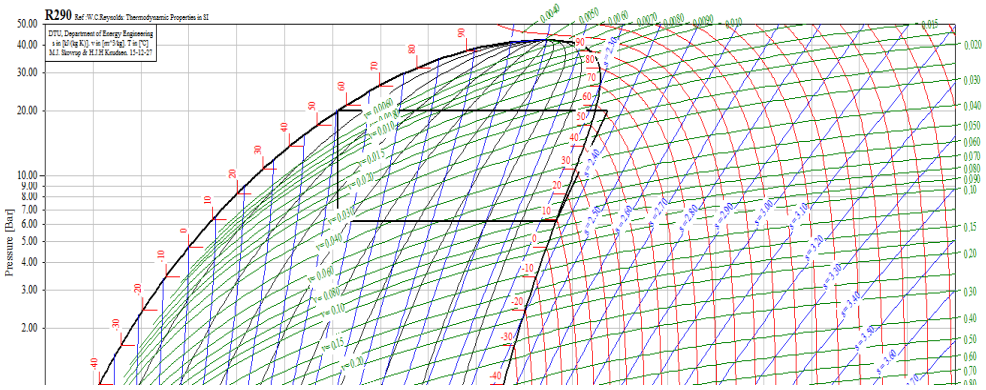
Tabel L2.1 Propertis Efisiensi HE 75 Psi

Temperatur air ACWH	: 58,1 ^{o}C
Temperatur air awal	: 32,7 ^{o}C
Temperatur pipa *in* ACWH	: 79,0 ^{o}C
Temperatur pipa *out* ACWH	: 48,1 ^{o}C
Temperatur pipa *out* Kondensor	: 36,4 ^{o}C
Temperatur pipa *out* evaporator	: 28,74 ^{o}C
Tekanan AC	: 75 Psi
Tekanan *out* Kompresor	: 275 Psi

- **Cycle 1**
  - Masukkan nilai Tekanan AC di *Evaporating Temperature* (ET).
  - Masukkan nilai Tekanan *out* kompresor di *Condensing Temperature* (CT).
  - Kemudian klik *draw cycle*. Maka akan terlihat grafik yang menunjukan kerja kompresor sampai *heat exchanger*.

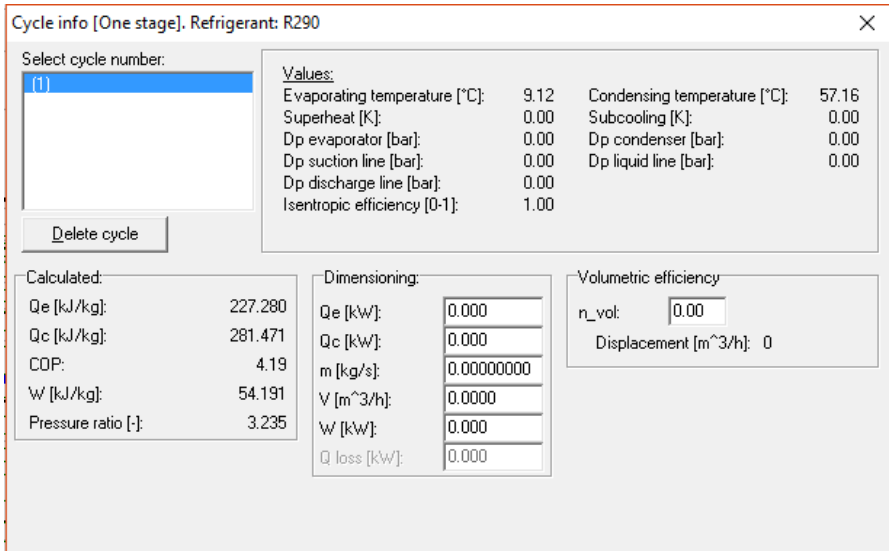


Gambar L2.1 *Cycle* 1 Coolpack pada Tekanan 75 Psi



Gambar L2.2 Grafik Hasil *Cycle* 1 pada Tekanan 75 Psi

- Kemudian klik *cycle* info untuk melihat nilai ET dan CT yang sudah dimasukkan.
- Nilai ET = 9,12^{o}C
- Nilai CT = 57,16^{o}C

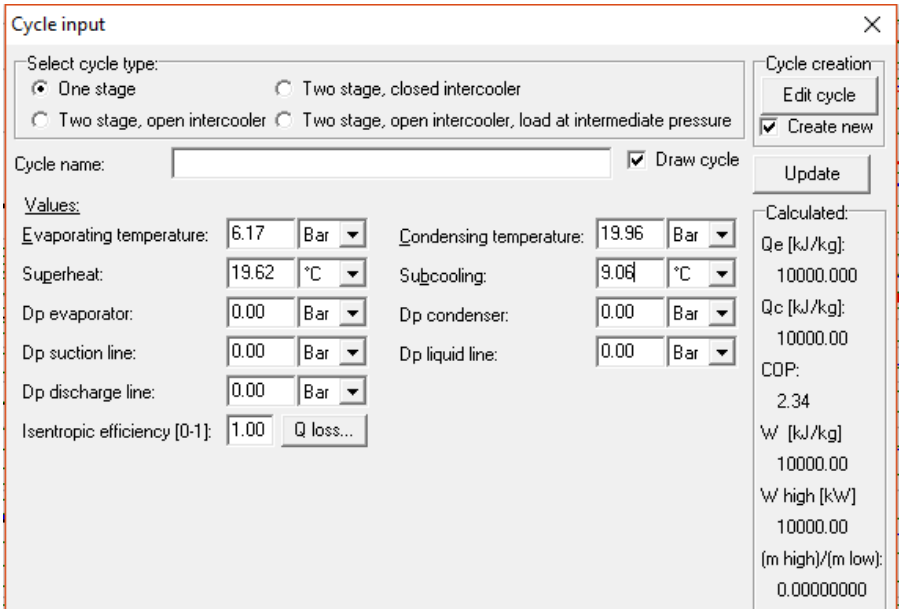


Gambar L2.3 *Cycle* 1 Info pada Tekanan 75 Psi

- **Cycle 2**

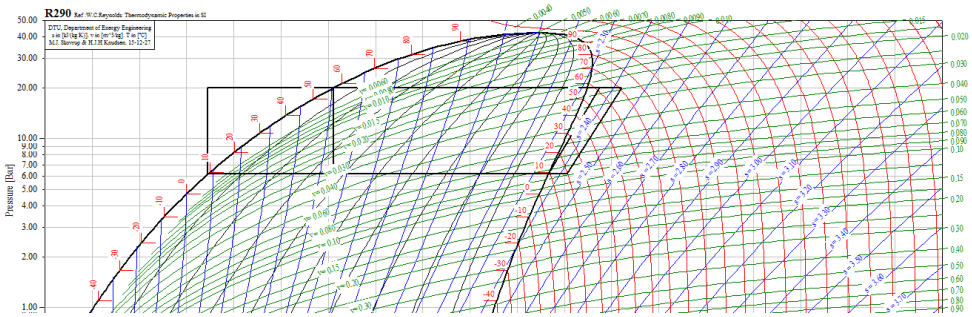
- Masukkan nilai Tek. AC di ET.
- Masukkan nilai Tek. *Out* kompresor di CT.

- *Superheat* = Tpipa *out* evaporator – ET = 28,74 – 9,12 = 19,62ºC.
- *Subcooling* = CT - Tpipa *out* ACWH = 57,16 – 48,1 = 9,06ºC.



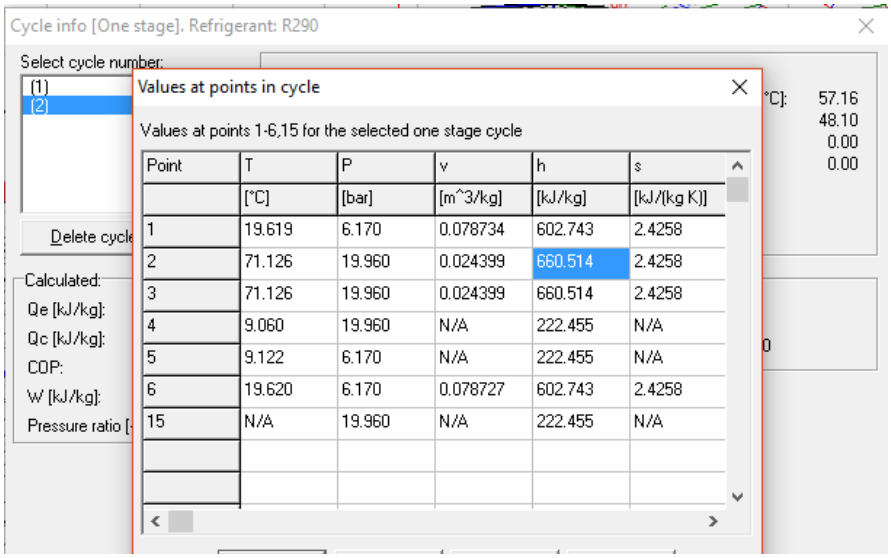
Gambar L2.4 *Cycle* 1 Info pada Tekanan 75 Psi

- Kemudian klik *draw cycle*. Maka akan terlihat grafik yang menunjukan kerja kompresor, *heat exchanger*, dan kondensor.



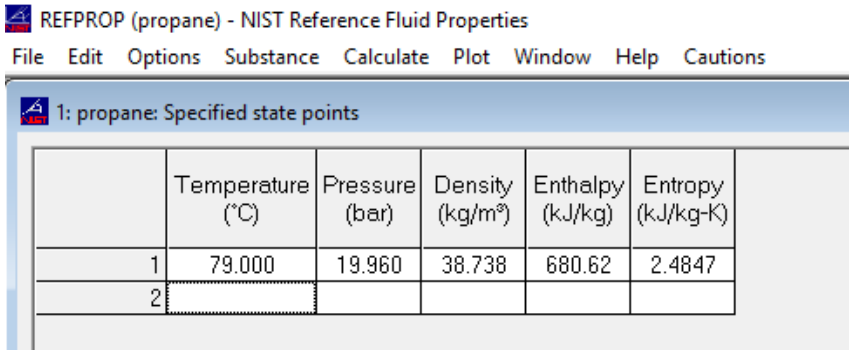
Gambar L2.5 Grafik Hasil *Cycle* 2 pada Tekanan 75 Psi

- Kemudian klik *cycle info*, pilih *cycle number* 2. Lalu klik *Coordinates of points*. Catat hasil dari h_1 dan h_2.
- Nilai h_1 = 602,743 kj/kg, $h_2 = h_{2s}$ = 660,514 kj/kg.



Gambar L2.6 *Values at point in cycle 2*

- Setelah itu, buka aplikasi Refprop untuk mencari h_2.
- Klik option unit, temperatur K menjadi ^oC, *pressure* Mpa menjadi bar.
- Klik *substance*, *purefluid* (*singel coumponds*), pilih propane, klik ok.
- Klik *calculate*, *spesifited state points*.
- Masukkan Tpipa in HE dan Tekanan *out* Kompresor, klik enter.



Gambar L2.7 *Refprop* pada Tekanan 75 Psi

- Hasil h_2 = 680,62 Kj/kg, setelah h_1, h_2, dan h_{2s} sudah dicari maka akan ketemu nilai efisiensi isentropik (η).
- $\eta = \frac{h2s - h1}{h2 - h1} = \frac{660{,}514 - 602{,}743}{680{,}62 - 602{,}743} = \frac{57{,}771}{77{,}877} = 0{,}7418$

- **Cycle 3**

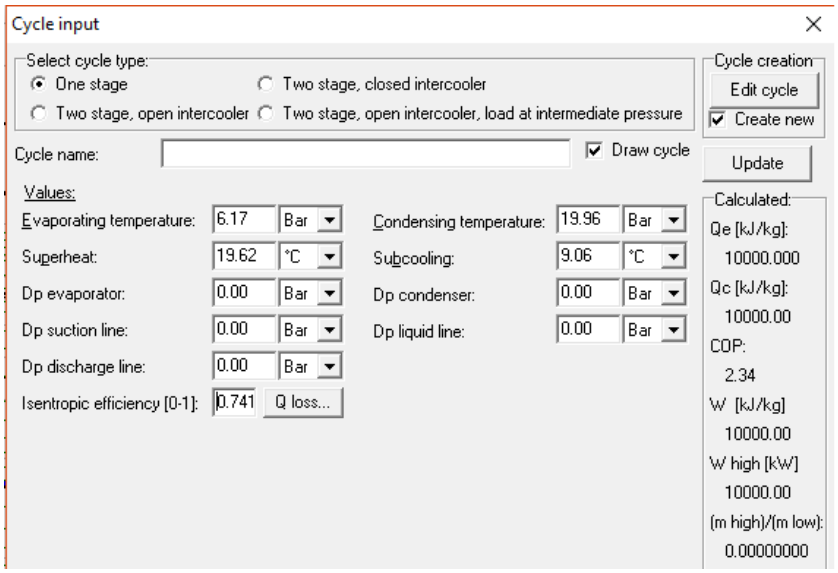
- Masukkan nilai Tek. AC di *Evaporating Temperature*

- Masukkan nilai Tek. *Out* kompresor di *Condensing Temperature*

- *Superheat* = Tpipa *out* evaporator – ET = 28,74 – 9,12 = 19,62^{o}C

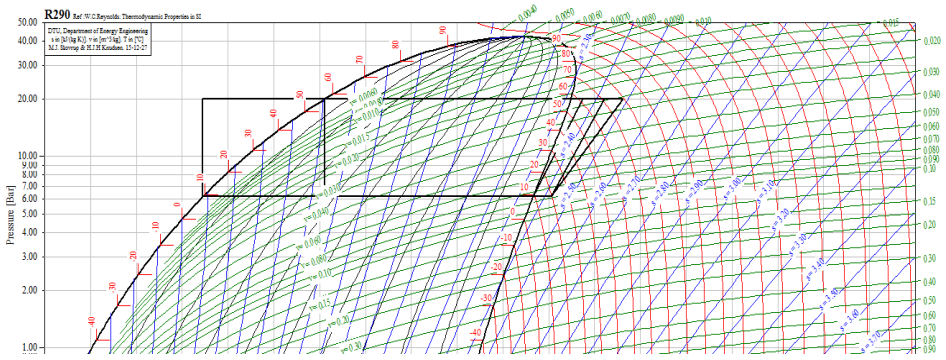
- *Subcooling* = CT - Tpipa *out* ACWH = 57,16 – 48,1 = 9,06^{o}C

- Masukkan effisiensi isentropik 0,7418



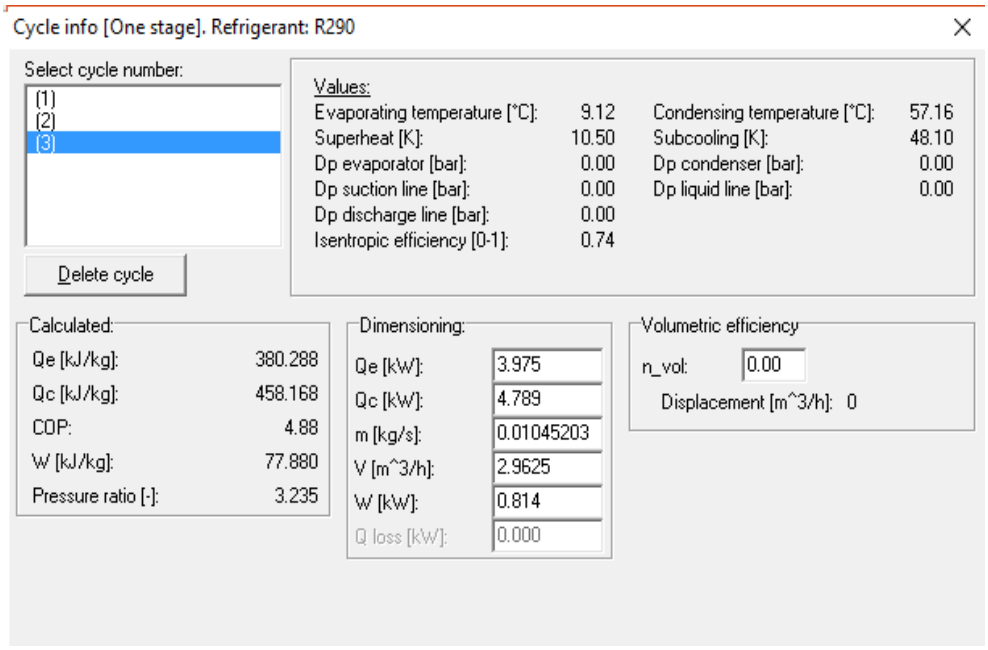
Gambar L2.8 *Cycle* 3 Coolpack pada Tekanan 75 Psi

- Klik *draw cycle*, maka akan keluar grafik dari hasil *cycle* 3.



Gambar L2.9 Grafik Hasil *Cycle* 3 pada Tekanan 75 Psi

- Kemudian pilih *cycle* 3 pada *cycle* info.
- Masukkan nilai watt yang dihasilkan kompresor pada *dimensioning*. Klik *update*.



Gambar L2.10 Hasil *Cycle* Info 3 pada Tekanan 75 Psi

- Qc = 4,789 Kw

- **Effisiensi *Heat Exchanger***

$$\eta = \frac{Qair}{Qc}$$

Qair = m.Cp.ΔT = $\frac{1000x0,05}{1800}$ x 4180 x (58,1-32,7) = 2949 w = 2,949 Kw

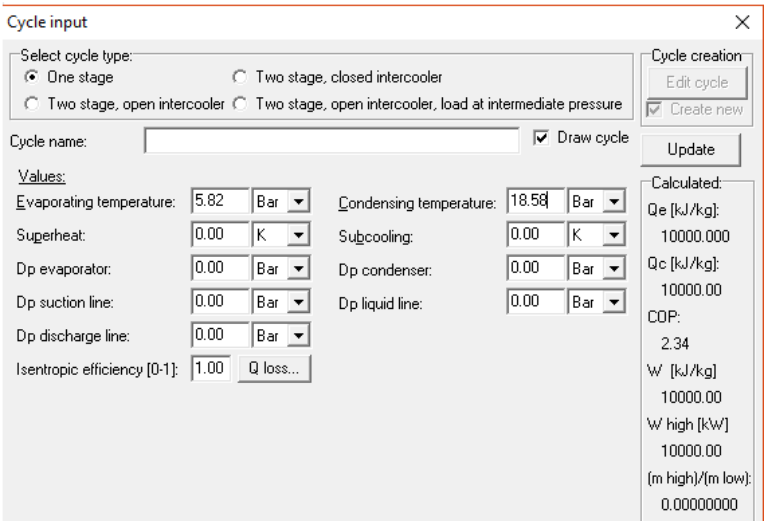
$$\eta = \frac{Qair}{Qc} = \frac{2,949}{4,789} = 0,6157 = 61,57\ \%$$

2. Efisiensi HE pada Tekanan 70 Psi

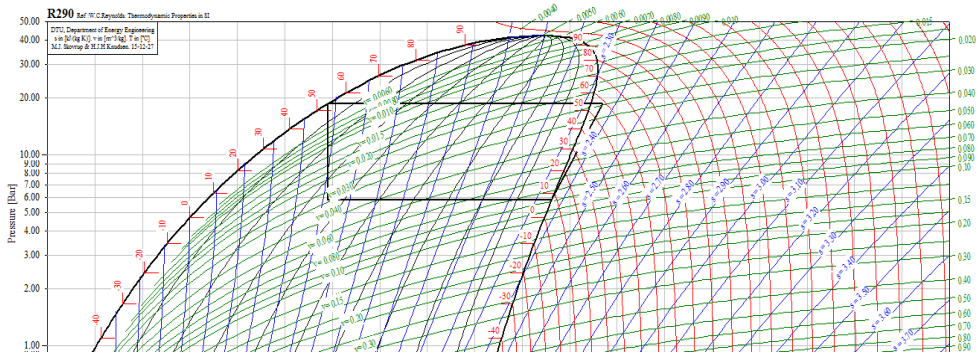
Tabel L2.2 Propertis Efisiensi HE 70 Psi

Temperatur air ACWH	: 58,4 ºC
Temperatur air awal	: 31,6 ºC
Temperatur pipa in ACWH	: 74,6 ºC
Temperatur pipa out ACWH	: 47,0 ºC
Temperatur pipa out Kondensor	: 36,8 ºC
Temperatur pipa out evaporator	: 26,35 ºC
Tekanan AC	: 70 Psi
Tekanan out Kompresor	: 255 Psi

- **Cycle 1**
  - Masukkan nilai Tekanan AC di *Evaporating Temperature* (ET).
  - Masukkan nilai Tekanan *out* kompresor di *Condensing Temperature* (CT).
  - Kemudian klik *draw cycle*. Maka akan terlihat grafik yang menunjukan kerja kompresor sampai *heat exchanger*.

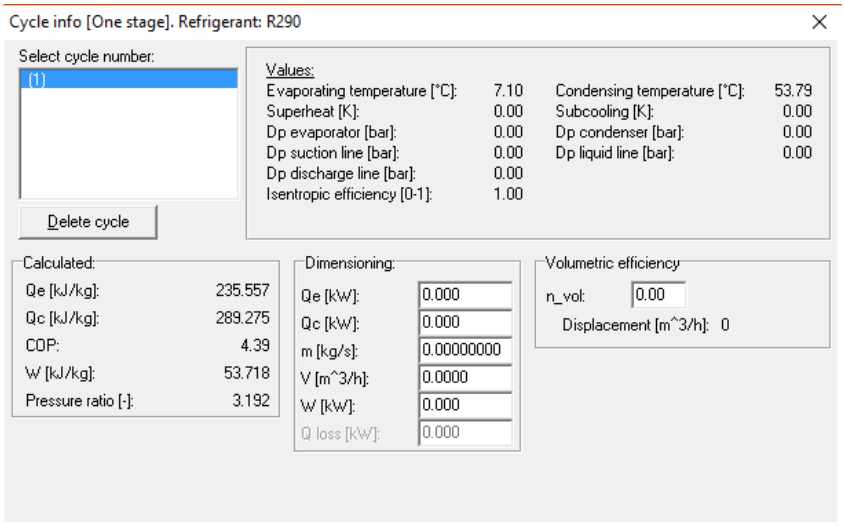


Gambar L2.11 *Cycle* 1 Coolpack pada Tekanan 70 Psi



Gambar L2.12 Grafik Hasil *Cycle* 1 pada Tekanan 70 Psi

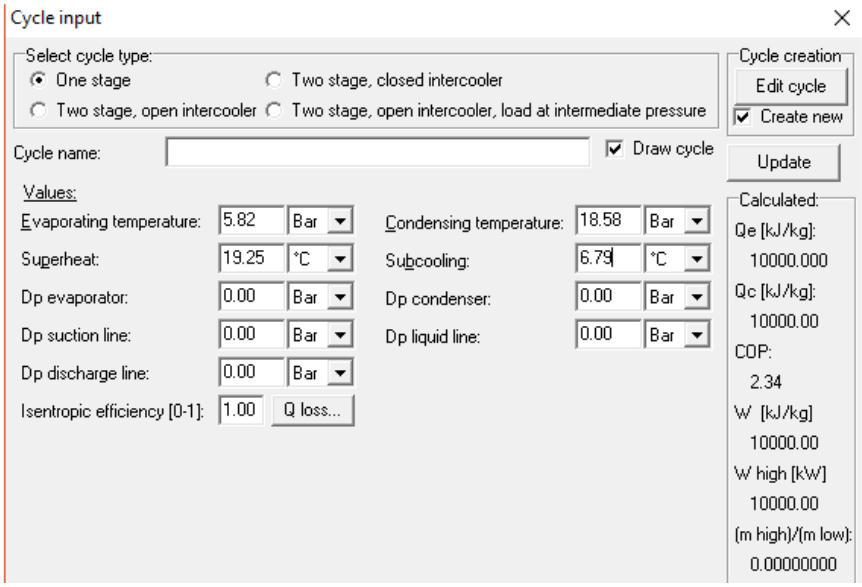
- Kemudian klik *cycle* info untuk melihat nilai ET dan CT yang sudah dimasukkan.
- Nilai ET = 7,10^{o}C
- Nilai CT = 53,79^{o}C



Gambar L2.13 *Cycle* Info 1 pada Tekanan 70 Psi

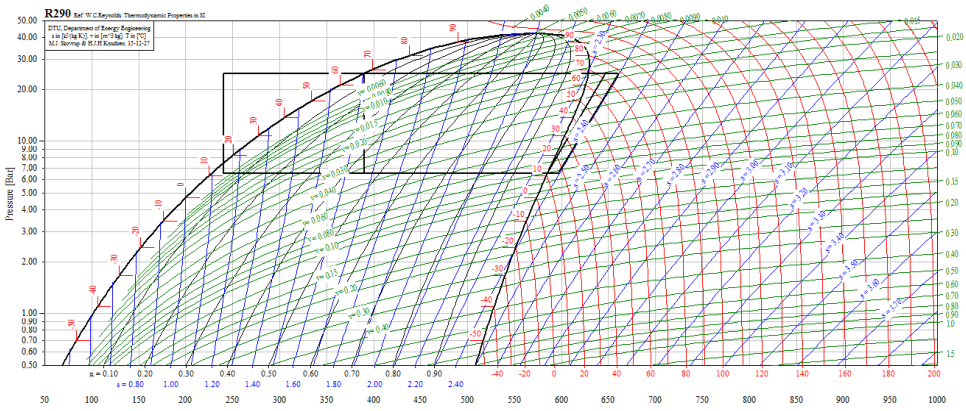
- **Cycle 2**
  - Masukkan nilai Tek. AC di ET.
  - Masukkan nilai Tek. Out kompresor di CT.
  - *Superheat* = Tpipa *out* evaporator – ET = 26,35 – 7,10 = 19,25^{o}C.

- *Subcooling* = CT - Tpipa *out* ACWH = 53,79 – 47,0 = 6,79ºC.



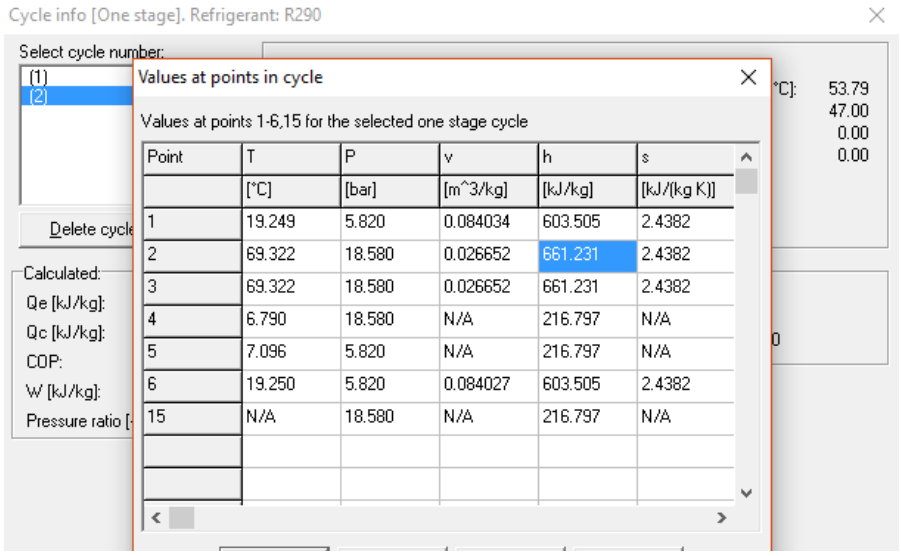
Gambar L2.14 *Cycle* Info 2 pada Tekanan 70 Psi

- Kemudian klik *draw cycle*. Maka akan terlihat grafik yang menunjukan kerja kompresor, *heat exchanger*, dan kondensor.



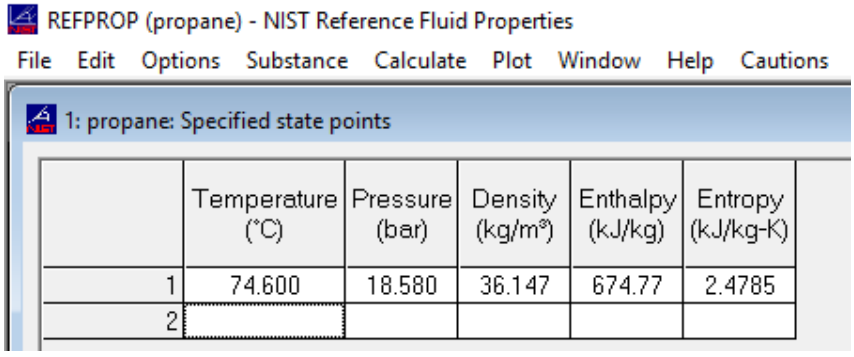
Gambar L2.15 Grafik Hasil Cycle 2 pada Tekanan 70 Psi

- Kemudian klik *cycle info*, pilih *cycle number* 2. Lalu klik *Coordinates of points*. Catat hasil dari h_1 dan h_2.
- Nilai h_1 = 603,505 kj/kg, $h_2 = h_{2s}$ = 661,231 kj/kg.



Gambar L2.16 *Values at point in cycle* 2

- Setelah itu, buka aplikasi Refprop untuk mencari h_2.
- Klik option unit, temperatur K menjadi ^oC, *pressure* Mpa menjadi bar.
- Klik *substance*, *purefluid* (*singel coumponds*), pilih propane, klik ok.
- Klik *calculate*, *spesifited state points*.
- Masukkan Tpipa *in* HE dan Tekanan *out* Kompresor, klik enter.



Gambar L2.17 *Refprop* pada Tekanan 70 Psi

- Hasil h_2 = 674,77 kj/kg, setelah h_1, h_2, dan h_{2s} sudah dicari maka akan ketemu nilai efisiensi isentropik (η).

- $\eta = \frac{h2s - h1}{h2 - h1} = \frac{661{,}231 - 603{,}505}{674{,}77 - 603{,}505} = \frac{57{,}726}{71{,}265} = 0{,}81$

- **Cycle 3**

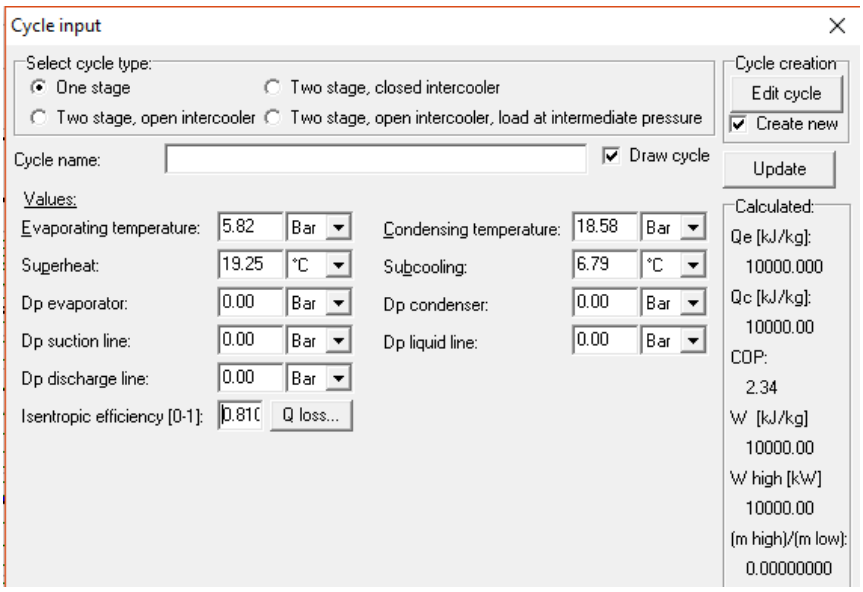
- Masukkan nilai Tek. AC di ET.

- Masukkan nilai Tek. *Out* kompresor di CT.

- *Superheat* = Tpipa *out* evaporator – ET = 26,35 – 7,10 = 19,25^{o}C

- *Subcooling* = CT - Tpipa *out* ACWH = 53,79 – 47,0 = 6,79^{o}C

- Masukkan effisiensi isentropik 0,81

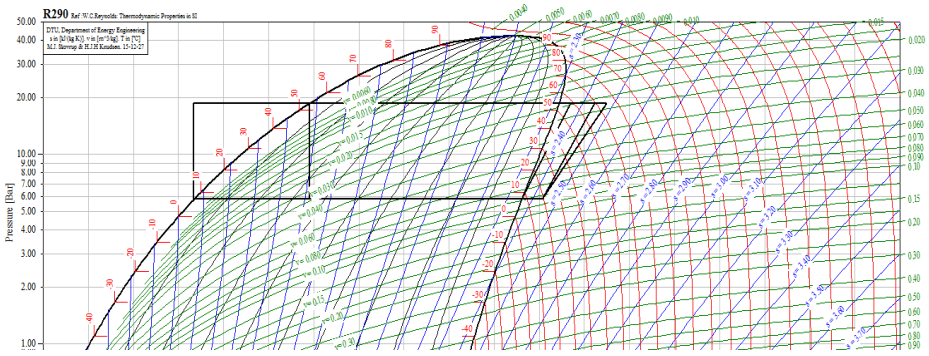


Gambar L2.18 *Cycle* 3 Coolpack pada Tekanan 70 Psi

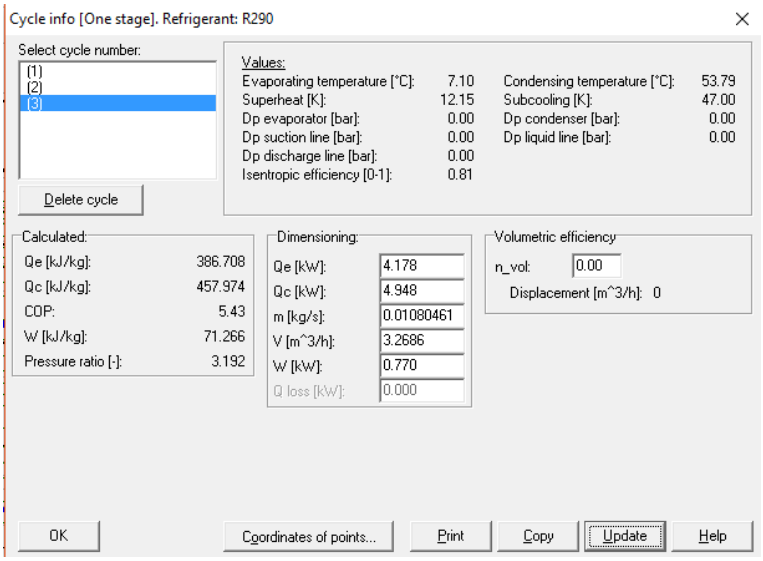
- Klik *draw cycle*, maka akan keluar grafik dari hasil *cycle* 3.

- Kemudian pilih cycle 3 pada cycle info.

- Masukkan nilai watt yang dihasilkan kompresor pada *dimensioning*. Klik update.



Gambar L2.19 Grafik Hasil *Cycle* 3 pada Tekanan 70 Psi



Gambar L2.20 Hasil *Cycle* Info 3 pada Tekanan 70 Psi

- Maka pada bagian *dimensioning* akan keluar hasilnya.
- Q_c = 4,948 Kw.

- **Effisiensi *Heat Exchanger***

$$\eta = \frac{Qair}{Qc}$$

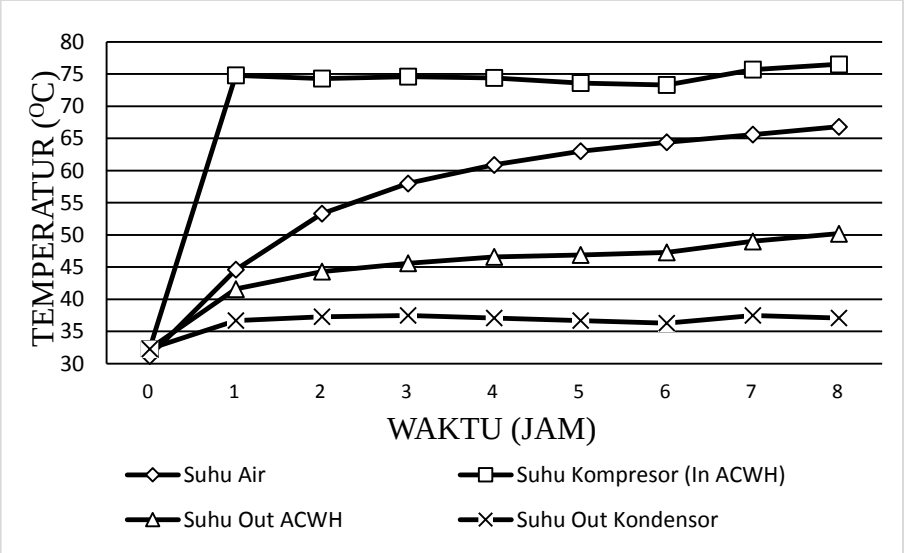
Qair = m.Cp.ΔT = $\frac{1000x0,05}{1800}$ x 4180 x (58,4-31,6) = 3112 w = 3,112 Kw

$$\eta = \frac{Qair}{Qc} = \frac{3,112}{4,948} = 0,628 = 62,8\ \%$$

Lampiran 3 Pengujian 8 Jam ACWH Pada Tekanan 70 Psi

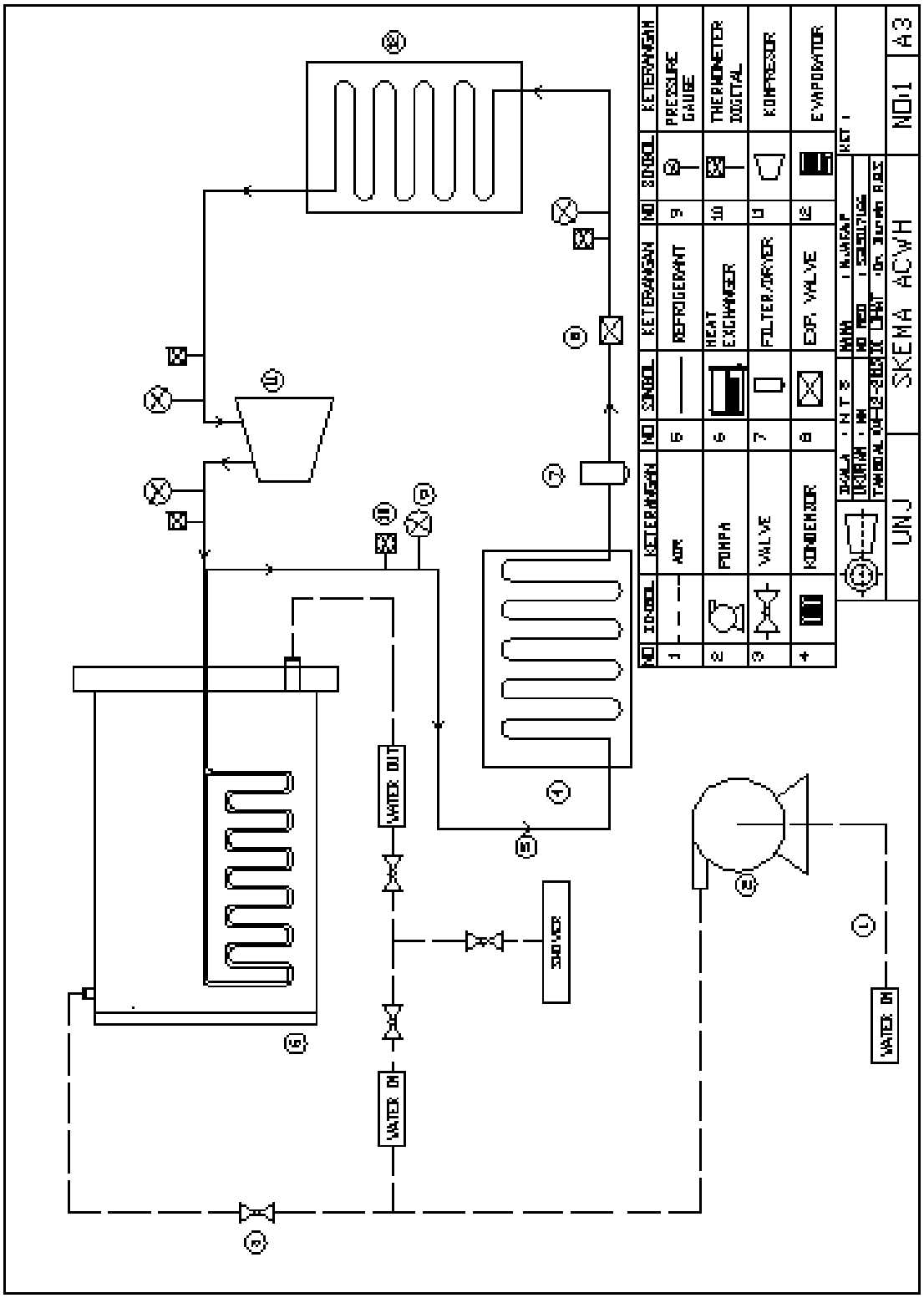
Tabel L3.1 Pengujian 8 Jam ACWH 70 Psi

Waktu	Temperatur Air	Temperatur Kompresor (In HE)	Temperatur Out HE	Temperatur Out Kondensor
0	31,2	32,3	32,3	32,3
1	44,6	74,8	41,6	36,7
2	53,3	74,3	44,3	37,3
3	58,0	74,6	45,6	37,5
4	60,9	74,4	46,6	37,1
5	63,0	73,6	46,9	36,7
6	64,4	73,3	47,3	36,3
7	65,6	75,7	49,0	37,5
8	66,8	75,2	50,2	37,1

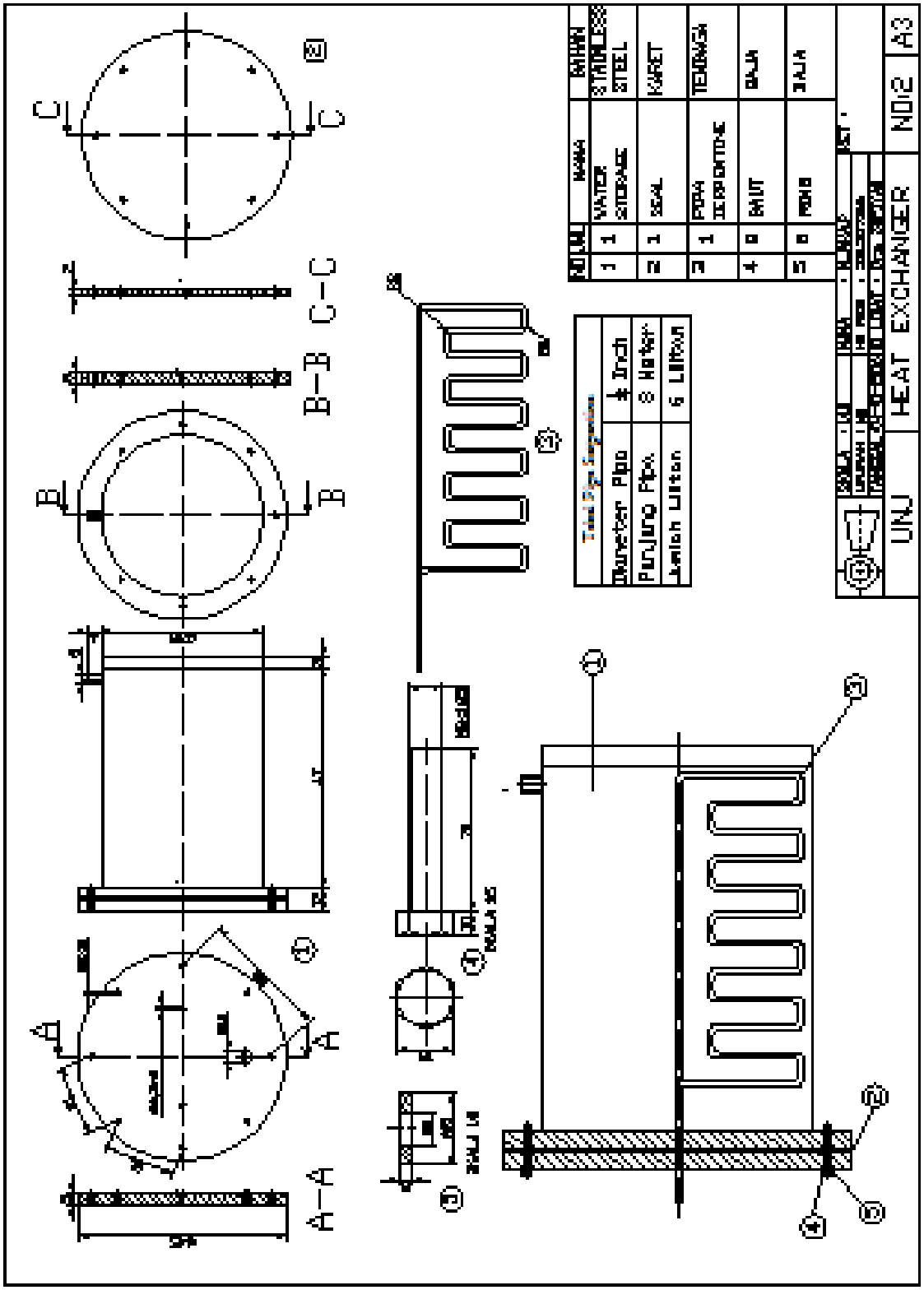


Gambar L3.1 Grafik Temperatur ACWH Pengujian 8 Jam 70 Psi

Lampiran 4 Skema ACWH



Lampiran 5 *Heat Exchanger*



Lampiran 6 *Heat Exchanger*